

**Proposal for
Roger Williams University
Aquaculture Technology Park**

Presented to the partnership of:

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Theory of Operation Outline

Project Scope:

The scope of this project is to design and build a land-based aquaculture office park that will provide leased space complete with a clean and constant source of treated seawater to individuals or groups that would like to perform research using aquatic organisms. Infrastructure would include seawater intakes, prefiltration, significant storage capacity, consistent pressurized delivery, and discharge treatment capabilities.

Location:

Site location is not finalized at this point. In order to complete the analysis and design, a number of assumptions have been made in regards to topography and layout. These assumptions are detailed below.

List of Site Assumptions:

1. The location will have access to raw seawater.
2. To achieve 15' intake depth, a max of 400 linear feet of piping would need to be run.
3. The pump house would be located no greater than 20 vertical feet above the low tide line.
4. The foundation of the storage tanks would be located no greater than 50 vertical feet above the foundation pump house.
5. All suites to receive water would be located at an elevation between the foundation of the storage tanks and an adequate elevation above the pump house for gravity drainage.
6. The topographical gradient would be no greater than a 10' rise over a 100' run.

Saltwater Source Conditions

All sites are located on a coastal Bay with access to Class B Water (closed during and after rainfall). Intake lines will be run for source water. Seasonal temperature range is from 5 deg C to 25 deg C. Discharge permits must be obtained that will provide a total discharge rate of 225 gallons per minute (gpm) of saltwater.

Water delivered to tenants will be initially screened at the intakes to restrict the induction of large particles. Intake lines will also be equipped with strainer baskets. Strainer baskets will serve as secondary protection to ensure that organisms and debris not filtered by the original intake screen (that may attach and / or grow in an intake line) do not get dislodged and pulled through the pump. Incoming water will then pass through a sand filter to remove microorganisms that could further foul system plumbing. These filters will be followed by ultraviolet (UV) disinfection units sized to provide 30,000 microwatt-sec /cm² of disinfection. This process flow will enable the delivery of cleaned seawater to the storage vessels; from which said water can be distributed to the tenants.

Marine Biotech makes no other representation as to the quality of the incoming water. This is a factor that will remain uncontrollable and change with seasons, rainfall, planktonic blooms, etc. The system will be equipped to recirculate its discharge line in the event that seawater is not fit for treatment and delivery. In this event city water and synthetic sea salt would be added to dilute nitrate-nitrogen (N) accumulation and allow tenants a window of operating continuity.

Discharge Characteristics

The accumulated metabolites in most recirculation systems will be nitrate-nitrogen (N). Ammonia-N and nitrite-N will be continuously oxidized within each suite by the suite-level biofiltration capabilities. A biofilter will also be provided on the discharge line to provide backup for this process.

Assumed Discharge Concentrations required:

Ammonia-N	0.050	mg/l
Nitrite-N	0.025	mg/l
Nitrate-N	50.0	mg/l
Total Suspended Solids (TSS)	10.0	mg/l
Biochemical Oxygen Demand (BOD)	6.0	mg/l
Salinity	35.0	g/l

These effluent concentrations are calculated assuming the following influent concentrations:

Ammonia-N	0.00	mg/l
Nitrite-N	0.00	mg/l
Nitrate-N	0.00	mg/l
Total Suspended Solids (TSS)	2.0	mg/l
Biochemical Oxygen Demand (BOD)	2.0	mg/l
Salinity	35.0	g/l

Carrying Capacity

In order to maintain nitrate-N at the level listed above, nutrient inputs will need to be regulated. Assuming that most of the tenants using this resource would fall under the category of “researcher” and not “intensive culturist”, nitrate-N concentration in the effluent should not be an issue. However, in the event that there are tenants who will require intensive (commercial) feeding scenarios, a restriction on nutrient loading would need to be instituted.

For tenants in a commercial feeding scenario, this can be looked at as a maximum mass of protein added to their system per day, per unit of flow (gpm). For tenants in a biomass holding scenario (e.g. lobsters), this could be dealt with as a maximum biomass holding capacity per unit of flow (based on holding temperature). Customers can theoretically increase their loading capacity on a system that is nitrate-N excessive by adding de-nitrification within their recirculated unit process loop.

With an assumed nitrate-N effluent concentration of 50 mg/l and no denitrification process in place, an estimation of allowable protein to be added to a system is approximately 3.2 kg per day per 1 gpm of flow-through seawater. For a system that uses 10 gpm of flow-through seawater, this would be the equivalent of feeding 168 lbs. of a 42% protein feed over the course of a day.

The most logical way to control effluent concentrations for any parameter is to enforce the same initial effluent restrictions to each tenant and require water quality monitoring data from each tenant on a daily basis, supplemented by random independent testing. As long as each individual tenant maintains adequate effluent concentrations, the overall main effluent restriction will be satisfied. If issues arise, either the tenant can purchase more water, can increase process filtration or can change their culture conditions.

Process Flow

1. Passive Intake Screen

There will be two intake screens fitted with 2.0 mm mesh. Each will be capable of sustaining the maximum rated system flow of 225 gpm. The approach velocity will be 0.5 ft/sec at 225 gpm. These intakes will be connected to the intake plumbing and suspended in the water column using floats and moorings. Top-water service will be accessible from a barge via a hydraulic lift after disconnecting the intake plumbing. Certified SCUBA divers may occasionally be required for underwater service.

2. Pump Intake Plumbing

The intake plumbing will consist of dual Sch.40 PVC intake lines each capable of drawing 225 gpm. A compression coupling will be fitted for each of the intake screens. This plumbing will not be buried, but will be attached to the ocean floor using ballast every at approximately every 5 to 10 feet. The run length for each line, from screen to pump, is estimated at 400 feet. Each pump intake line will be fitted with a filter basket and check valve. These can be backwashed from the sand filter backwash reservoir.

3. Filtration House

A steel framed building with ventilation and propane heaters will be required to house all raw water pumps and filters as well as the discharge treatment units. This filtration house will require electrical utilities, city water and sewer. There will also need to be a temporary access road, single lane, unpaved. The overall footprint of the building would need to be approximately (20' x 30') with an overhead door for equipment access. This has all been represented in the budget estimates.

4. Pumping

The design requirement for total seawater flow is 225 gpm at maximum system capacity. This flow will be produced by [3] 75 gpm pumps, with one backup pump plumbed in line and rotated into service on a regular basis. All pumps will be located in the filtration house. Depending upon the level of water usage at any given time, either one, two or all three pumps will be running in order to maintain water level in the holding tanks (manual devices). The pumps will be self-priming to a suction level of 20 feet. Priming can also take place using the discharge reservoirs as the intake. Total head loss through plumbing and elevation change is calculated at approximately 150' at 5 deg C. Pumps will be rated for 75 GPM at 65 PSI.

5. Discharge Plumbing

All pump outlets will be delivered into a main manifold. This manifold will have a valved recirculation port that will bypass all filtration and deliver water directly to the drainage reservoir. This port should be used when first priming the pump. Doing so will reduce the pressure on the pump outlets and avoid water hammer on the filtration component. The manifold will also have a valved discharge port directed to the first of the filtration components; the sand filters.

6. Sand Filters

There will be [3] 36" diameter sand filters plumbed in parallel to each other on the main discharge line of the pumps. These filters will have an automated backwash with a dedicated backwash pump and reservoir. The reservoir will be filled slowly from the treated delivery line. Backwashed water will be plumbed to the clean water drainage and drained to sea. Each backwash will be in the amount of approximately 450 gallons. Backwash will be initiated on a timed basis. Filters will be backwashed one at a time and rotate through a regular cycle. The main pumps will continue to deliver water to the filters that are not being backwashed. Each filter should be backwashed every day at 150 gpm for 3 minutes.

The backwash reservoir capacity will be 500 gallons. Refill rate for the reservoir will need to be at least 1.0 gpm. Backwash intervals are every 8 hours. The sand filter backwash reservoir will also be plumbed to perform a backwash on the intake line.

7. Ultraviolet (UV) Disinfection

There will be [3] UV disinfection units, each designed to deliver 30,000 microwatt-sec/cm² of UV irradiation at a flow rate of 75 gpm. These units will be plumbed in series and will require a signal from a pump and flow sensor in order to maintain operation. Flow from the sand filters will join in a manifold and pass through all three UV sterilizers. If a single pump is running, a single UV disinfection unit will be running. If flow is not registered on the outlet to the UV unit then no UV unit will be powered. If all three pumps are running, all three UV sterilizers will be activated. The customer will have the option to run the pumps without operating the UV units, but not vice versa.

Electrical control boxes are included in the budgetary estimates for the pumps and UV units.

8. Treated Water Plumbing

The treated water will be plumbed through a buried and insulated 4" diameter main line. This main line run is estimated at a maximum of 500', with a maximum elevation change of 50'. There will be a 6" diameter manifold at the base of the three storage tanks. Water will enter this manifold and be delivered to all three storage tanks through 4" diameter valved lines. Water will enter the storage tanks at the top in order to prevent back siphoning.

9. Storage / Header Tanks

Three storage tanks will be placed at an elevation that is high enough to deliver water by gravity to all of the tenant buildings / suites. These tanks will come on-line as storage capacity increases with the number of users. The header tanks will be designed to hold enough water to deliver 10% of the normally delivered flow rate over a 24-hour period (20 gpm). This would approximate a 1% water change for 'recirculation systems' and 10% of the normal flow for 'flow-through' systems. This design requires [3] 10,000 gallon holding tanks (11'Ø x 14'H). The storage tanks will be insulated and capped to keep sunlight out and to be suitable for outdoor water storage in New England. The storage tanks will have overflow ports to discharge unused water and maintain a constant delivery head pressure. Unused water in the amount of 18 gpm will bypass the discharge treatment facility and be discharged directly to sea. Drainage and equalization lines and isolation valves will also be incorporated on each tank. Turnover rate for the storage tanks

would be just under 11 times per day. A steel reinforced concrete slab will be required in the dimensions of (20' X 40') and able to carry a floor load of 900 psf.

10. Delivery Line and Control Building

The header tank will deliver water to a distribution manifold located inside a climate-controlled equipment building. The manifold will consist of one 4" diameter main line with [20] valved 1" diameter line drops equipped with electrical flow meters and a flow totalizer. This will allow tenants to request flow in 10 GPM increments. Tenants requiring 20 gpm would be charged to join two of the 1" line drops after the flow meters and to run the appropriately sized plumbing to the suite (insulated or buried). The two associated flow meters would be totalized to monitor water usage for that customer.

11. Drainage Line

Marine Biotech will supply an estimate on a buried main drainage pipe that is 8" in diameter and 100' long. Five 3" diameter legs will be provided whereby tenants can connect to the drainage (below grade). This drainage line will terminate at the filtration house where it will enter its first unit process; solids removal.

12. Drum Filter

All water returning from tenant suites will pass through a micro-screen drum filter on automated backwash before discharge into the ocean. The drum filter screen size will be 60 microns. The backwash water source will be treated incoming seawater. The discharge from the spray down will be delivered to the city sewer system.

13. Drainage Reservoir and Fluidized Sand Biofilter

The effluent from the drum filter will be delivered to a partitioned reservoir dimensioned at 6'W x 12'L x 4'D. The pump intakes delivering water to the fluidized sand biofilter will be in the first partitioned section. Approximately 400 gpm will be drawn from this section, run through the biofilter, and then delivered to the second section. Approximately 200 gpm will flow back into the first section and 200 gpm will flow out the overflow port to waste. The fluidized sand biofilter will be 60" in diameter and will process the system effluent on an average of two times prior to its discharge to sea.

There will be a valved outlet in the second section of the reservoir to supply water to the main intake pumps in the event that the system needs to be closed and recirculated.

14. Discharge Plumbing

Discharge plumbing will be provided from the drainage reservoir overflow port to 20 linear feet beyond the low tide line. This will be an exposed Sch.40 PVC line that is 8" in diameter with an assumed run of 100 ft.

15. Clean Water Drainage

A clean water drain line will be run from the storage towers to the pump house (6" diameter x 500' long). There it will join with the effluent from the drainage reservoir to be discharged to

sea. There will be a valved option to return this flow to the drainage reservoir during closed loop (recirculation) operation.

Budget Estimate

The figures below represent Marine Biotech's estimate of the entire costs to design, procure, manufacture, deliver and install the system(s) as described above. Various factors (e.g. final design configuration, siting, inflation, etc...) will influence these estimates. The figures provided are only estimates and do not represent a formal quotation on the part of Marine Biotech. Marine Biotech believes that the Project could be completed for a figure within +/- 20% of the estimate below, notwithstanding the effect of factors beyond its ability to forecast (as noted above).

Marine Biotech has attempted to be extremely thorough in its estimates. The costs of moorings, footings, buildings (installed), electrical control boxes and electrician, buried pipe runs, components, etc... are all included in this estimate. Where questions might arise over particular system sections, Marine Biotech can provide further clarification.

Marine Biotech's estimate for the turnkey installation of the proposed project (exclusive of tenant buildings / suites) is:

SYSTEM SECTIONS	PRICE
Engineering	32,000.00
Site Meetings	3,750.00
Passive Intake Screens	7,625.00
Pump Intake Plumbing	20,385.00
Filtration House	58,545.00
Control House	18,950.00
Pumping	47,295.00
Sand Filter	23,365.00
UV Sterilization	15,115.00
Treated Water Plumbing	2,410.00
Storage Tanks	76,055.00
Storage Water Delivery	20,750.00
Main Drainage Line	2,300.00
Drum Filter	21,025.00
Fluidized Bed Biofilter	12,150.00
Drainage Reservoir	5,345.00
Discharge Plumbing	1,015.00
Discharge Drainage	1,290.00
Clean Water Drainage	11,115.00
Spares	16,590.00
Supplies	945.00
SUB-TOTAL: SYSTEM COMPONENTS	\$398,020.00
Mobilization	5,880.00
SYSTEM: FOB VENDORS	\$403,900.00
Freight	24,445.00
Install	79,770.00
SYSTEM: DELIVERED AND INSTALLED	\$508,115.00

Operational Costs

Electricity:

The process flow system will require [1] 4-wire, 300 Amp, 3 phase service located at the filtration house. This installation cost is estimated in the filtration house utilities cost. This service will also feed the control house:

Energy Requirements for Filtration House:

	Required	Operational
Background lights, wall outlets and ventilation (120V)	20 Amps	30%
Heating (230V)	30 Amps	40%
Pumping (240 V) 3 PH	120 Amps	70%
UV Sterilization (240 V)	10 Amps	100%
Sand Filter Backwash Pump (240 V)	15 Amps	5%
Fluidized Sand Biofilter (Pump) (240 V)	30 Amps	100%
Drum Filter (240 V)	5 Amps	30%

Average daily KW Usage: **825 KW-HR/Day**

Energy Requirements for Control House:

	Required	Operational
Background lights, wall outlets and ventilation (120V)	20 Amps	30%
Heating (230V)	10 Amps	40%
Flow Meters and Totalizer	30 Amps	100%

Average Daily KW Usage: **150 KW-HR/Day**

Total Estimated Daily KW Usage: 975 KW-HR/Day

Personnel

Marine Biotech estimates that the daily service and maintenance requirements on this system would be the equivalent of one full-time or two part-time positions (\$18.00 / Hour * 1.6 Burden * 8 Hrs / Day = \$230.40 / Day.)

Tasks would include daily service checklist on all system components:

1. Pump Operation
2. UV Operation
3. Sand Filters
4. Backwash Operation
5. Drum Filter
6. Fluidized Bed Biofilter
7. Storage Tanks
8. Intake Water Quality
9. Effluent Water Quality
10. Monitor and Record Flow Rate to Tenant Suites
11. Tenants' Request for Service
12. Grounds Keeping